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(54) Abstract Title
Antenna switching in a dual mode portable phone

(57) A dual mode portable phone has a receiving circuit 107 for a first communication system (e.g. PDC), which is connectable to a first antenna 101 or a second antenna 102 through a switching circuit 103 for diversity reception. A transmitting/receiving circuit 110 for a second communication system (e.g. PHS) is connected to the second antenna 103. When the receiving circuit 107 is disconnected from the second antenna, an impedance matching circuit 105 is connected its place. The matching circuit has an impedance equal to that of the disconnected receiving circuit 107 so that the transmitting/receiving circuit 110 does not see any impedance changes which would cause degradation in its transmission or reception.

Fig. 2

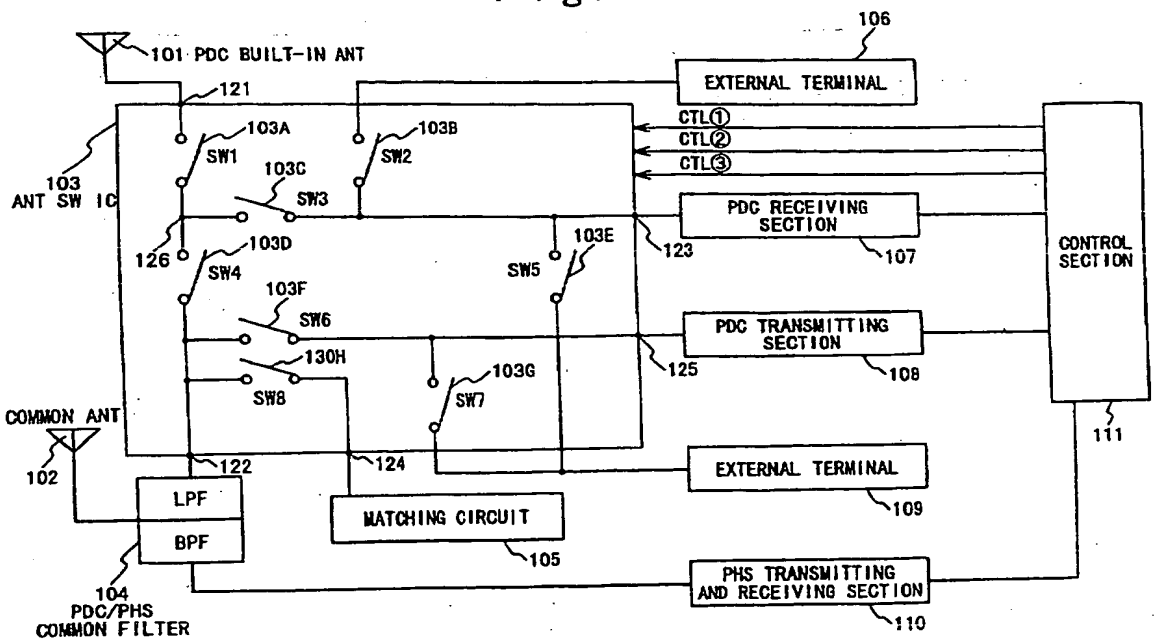

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Fig. 1 PRIOR ART

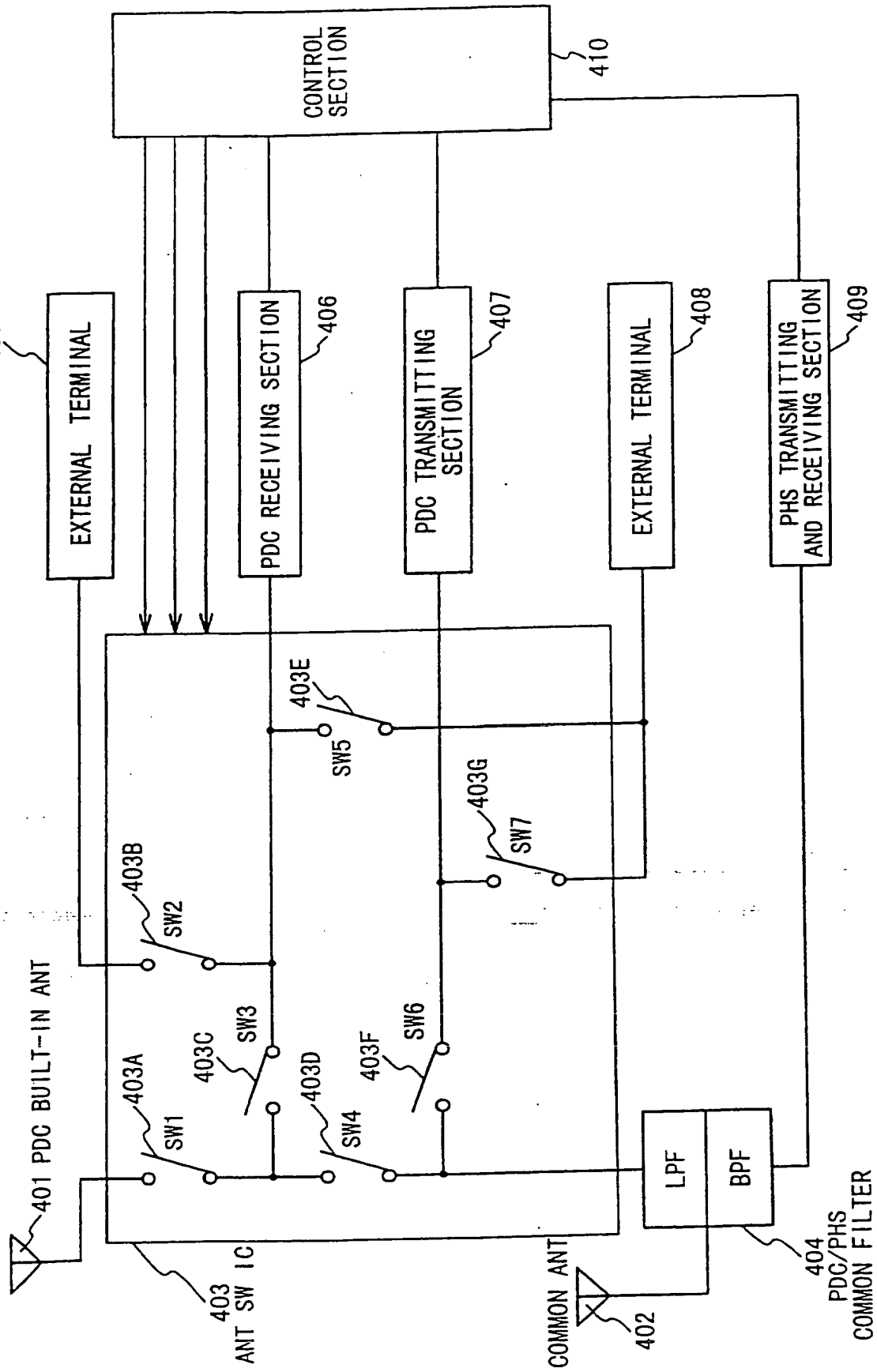
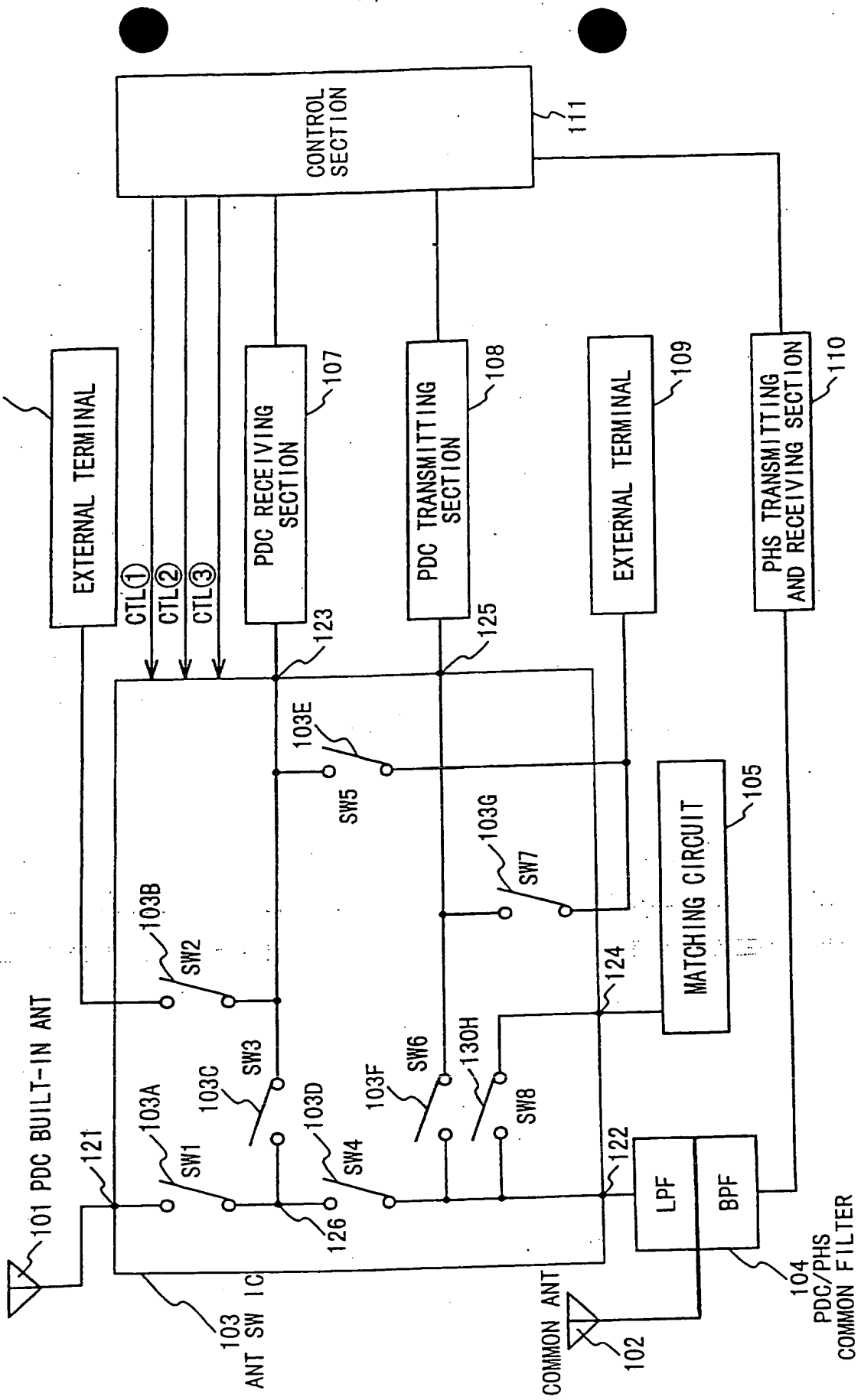


Fig. 2


CONTROL SECTION
111
EXTERNAL TERMINAL
106
PDC RECEIVING SECTION
107
PDC TRANSMITTING SECTION
108
EXTERNAL TERMINAL
109
PHS TRANSMITTING AND RECEIVING SECTION
110
CTL①
CTL②
CTL③
123
125
103E
SW5
103G
SW7
103B
SW2
MATCHING CIRCUIT
105
124
101 PDC BUILT-IN ANT
121
103A
SW1
103C
SW3
103D
SW4
103F
SW6
130H
SW8
122
126
LPF
BPF
104
PDC/PHS COMMON FILTER
103
ANT SW IC
COMMON ANT
102

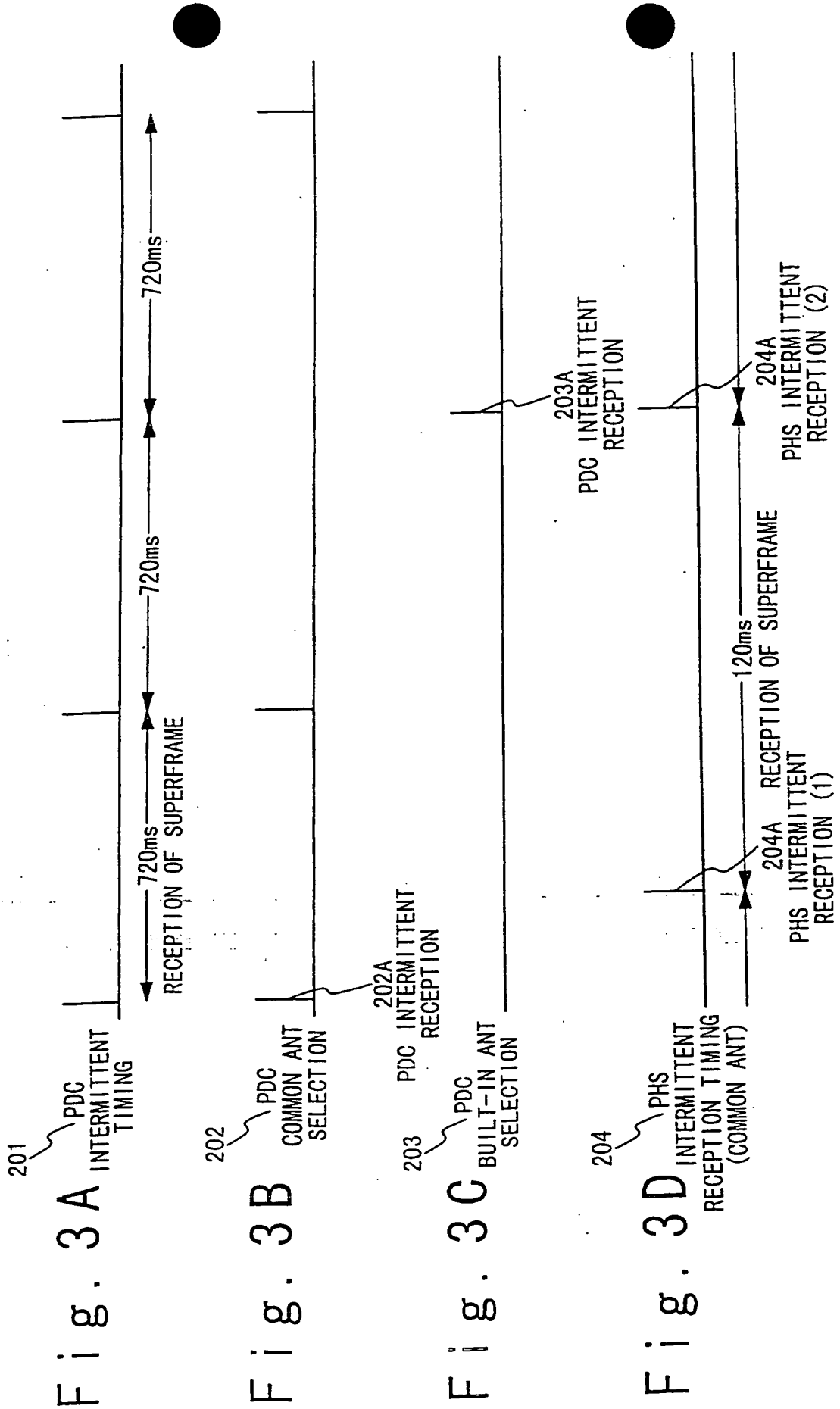


Fig. 3A

Fig. 3B

Fig. 3C

Fig. 3D

Fig. 4

	CONTROL LINE			STATE	SW STATES OF ANT SW IC 103							
	CTL①	CTL②	CTL③		SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
301	L	H	H	COMMON ANTENNA RECEPTION	OFF	OFF	ON	ON	OFF	OFF	OFF	OFF
302	L	L	H	BUILT-IN ANTENNA RECEPTION	ON	OFF	ON	OFF	OFF	OFF	OFF	ON
303	H	H	H	COMMON ANTENNA TRANSMISSION	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF
304	L	H	L	EXTERNAL TERMINAL 109 RECEPTION	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF
305	L	L	L	EXTERNAL TERMINAL 106 RECEPTION	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON
306	H	H	L	EXTERNAL TERMINAL 109 TRANSMISSION	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF

ANTENNA SWITCHING IN MULTIPLE RADIO TERMINAL

Background of the Invention

1. Field of the Invention

The present invention relates to a simple portable phone module built into a portable phone. More particularly, the present invention relates to a simple portable phone module built into a portable phone in which degradation in antenna switching of a transmission-and-reception characteristic can be prevented.

2. Description of the Related Art

A "multiple radio terminal" is known in which a simple portable phone (PHS) module is built-in a portable phone (PDC). The multiple radio terminal has a diversity antenna structure which uses a PDC and PHS transmitting-and-receiving common antenna (hereinafter, to be also referred to as a "PDC/PHS common antenna") and a PDC receive-only built-in antenna. An antenna switching integrated circuit is arranged between a PDC transmitting-and-receiving section and a PHS transmitting-and-receiving section.

Fig. 1 is a diagram showing a structure example of the PDC/PHS multiple radio terminal of this type. The PDC/PHS multiple radio terminal is composed of a PDC/PHS common antenna 402 and a

PDC built-in antenna 401 as the antenna structure. Also, the PDC/PHS multiple radio terminal is composed of an external terminal 408 and an external terminal 405 as the external input-output terminals. Moreover, the PDC/PHS multiple radio terminal is composed of a PDC receiving section 406, a PDC transmitting section 407 and a PHS transmitting-and-receiving section 409 as the transmission-and-reception structure.

The PDC/PHS common antenna 402 is connected with the PHS transmitting-and-receiving section 409 through a PDC/PHS common filter 404. Also, the PDC/PHS common antenna 402 is connected with the PDC receiving section 406 and the PDC transmitting section 407 through the PDC/PHS common filter 404 and an antenna switching circuit (ANT SW IC) 403. Also, the external terminals 408 and 405 are connected with the PDC receiving section 406 and the PDC transmitting section 407 through the antenna switching circuit 403. The PHS transmitting-and-receiving section 409, the PDC receiving section 406 and the PDC transmitting section 407 are connected with a control unit 410. Also, the antenna switching circuit 403 is composed of a plurality of switches SW1 403A to SW7 403G. Each of the switches 403A to 403 G is set to the ON/OFF state in

response to a control signal from the control unit 410. Thus, the switching control between the antenna and the transmitting-and-receiving section is carried out.

In such a PDC/PHS multiple radio terminal, an intermittent receiving operation is carried out in the reception-wait condition, to eliminate a problem in each signaling system, especially, in case of use on high-speed movement in an area, and in case of use in a underground town area. Also, in such a multiple radio terminal, in the reception-wait condition, each operation is not controlled finely, and the PDC side and the PHS side are controlled independently to operate asynchronously. This results in simplification of the circuit structure design and power consumption.

In the PDC/PHS multiple radio terminal as mentioned above, there is a case where the PHS side receives using the PDC/PHS common antenna during the reception in which the PDC side uses a built-in antenna. In this case, the conventional antenna switching circuit disconnects the PDC/PHS common antenna from the PDC receiving section. Therefore, the input/output impedance on PDC side of the PDC/PHS common filter becomes unstable. As a result, the matching condition shifts so that

the characteristic of the PDC/PHS common filter becomes worse, resulting in degradation of the transmission and reception characteristic on the PHS side. Therefore, especially, the following problem occurs.

The reception on the PHS side can not be carried out normally at an intermittent reception timing of the PHS side, in the state where the PDC side receives by use of the built-in antenna. As a result, there is a possibility that the synchronization of the reception timing on the PHS side goes out. Also, when the synchronization of the reception timing on the PHS side goes out, the operation to establish the synchronization of the reception timing once again becomes necessary on the PHS side to switch from the intermittent receiving operation to the continuation receiving operation for receiving the terminating call. As a result, the problem is caused that the power consumption increases further with the continuation of the receiving operation for such synchronous establishment.

In conjunction with the above description, a portable terminal is disclosed in Japanese Laid Open Patent Application (JP-A-Heisei 5-167566). In this reference, the portable terminal is composed of an antenna (1), a receiving section

(2), a data clock generating section (3), a first detection notifying section (4), a majority determining section (5), a second detection notifying section (6), and a central processing unit (7). The central processing unit (7) controls the receiving section (2) to stop based on a notice from the first detection notifying section (4) and the receiving section by a notice from the second detection notifying section (6). In this way, when a majority is determined before all data are received, a receiving circuit is stopped without reception of a remainder serial data. When the head of the following data format is detected, the receiving circuit is controlled to start an operation. Thus, low power consumption is realized.

Also, a diversity control method is disclosed in Japanese Laid-Open Patent Application (JP-A-Heisei 5-183475). In this reference, in each of n-system base station receiving sections (31, 3N), after a desired signal is extracted from an SD reception signal, the received electric field intensity levels of the desired signals are detected and compared with each other (317). A diversity switching control signal is generated based on the comparing result. A receiving switch section

(318) is driven in response to the diversity switching control signal to take out a demodulation signal of the desired signal of a system which has a higher received electric-field intensity level. A base station includes n-system base station transmitting sections(21, 2N) in addition to the n-system base station receiving sections (31, 3N). A transmission SD antenna is provided for the base station. A base-station transmitting section transmits a transmission signal to a mobile station using the transmission SD antenna switched based on the diversity switching control signal from the base station receiving section.

Also, a mobile radio apparatus is disclosed in Japanese Laid-Open Patent Application (JP-A-Heisei 5-316018). In this reference, a control data is transmitted from a base station. The control data is received by a receiving circuit (2) via an antenna (1) in a reception-waiting state, is demodulated by a digital data demodulating circuit (4), is subjected to a majority determining process by a majority determining circuit (5), and is analyzed by a microprocessor (6). Also, the control data is converted into digital data by an A/D converter (3). The microprocessor (6) determines the

reception electric-field intensity of the digital data and determines the number of words to be received within the control data to be repeatedly transmitted. The microprocessor (6) receives only the words of a predetermined number and controls the power source to the receiving circuit to be cut for a time from the head of the remaining words to the next sync signal.

Also, a personal handy phone is disclosed in Japanese Laid-Open Patent Application (JP-A-Heisei 8-116301). In this reference, the power supply to a transmitting circuit (3) is turned off and an antenna switch (2) is set to the receiving circuit (5), in a reception-waiting mode. A timer circuit (7) is connected to a call-identifying circuit (6) and the receiving circuit (5) by a control line (18) to control the power to be intermittently supplied to them. When the mobile phone is called from a base station during the intermittent operation, the identifying circuit (6) stops the timer operation and controls a ringing speaker (12). When a user carries out an off-hook operation, an LAP controller (9) is initiated to establish a link and a TDMA/TDD controller (4) starts the operation. Thus, the handy phone enters a communication mode.

Also, a radio apparatus is disclosed in Japanese Laid-Open Patent Application (JP-A-Heisei 9-27782). In this reference, a radio section (12) includes a receiving section for demodulating a receive data from a radio wave received by an antenna (11). A power supply control unit (14) controls the supply of power source (13) to the radio section (12) in an ON/OFF mode. A first timer (15) is set with a period of the ON/OFF control by the power supply control unit (14). A second timer (16) is set with a time longer than the ON time of the first timer (15). A control unit (20) controls the respective sections, and switches from the first timer (15) to the second timer (17) to allow the receiving section to receive data for longer time.

Summary of the Invention

An object of the preferred embodiment of the present invention is to provide a multiple portable phone in which the degradation of a transmission-and-reception characteristic on a PHS side, through an antenna switching operation on a PDC side, can be prevented.

Another object of the preferred embodiment of the present invention is to provide a multiple portable phone of a PDC-side diversity system in which the

suppression of power consumption and the prevention of going-out of synchronization in an intermittent receiving operation are made possible.

A multiple portable phone includes a first antenna for a first communication system, a second antenna common to the first communication system and a second communication system, and a switching circuit controlled based on a control signal. The multiple portable phone further includes a receiving circuit provided for the first communication system, and connectable to the first and second antennas via the switching circuit, and a transmitting-and-receiving circuit provided for the second communication system, and connectable to the second antenna, and an impedance-matching circuit connected to the switching circuit. A control unit generates the control signal to control the switching circuit to connect the impedance-matching circuit to a path from the second antenna to the transmitting-and-receiving circuit when the transmitting-and-receiving circuit carries out a receiving operation using the second antenna while the receiving circuit carries out a receiving operation using the first antenna.

The multiple portable phone may further include a common filter of a low-pass filter and a band-pass filter. In this case, the receiving circuit may be connected to the second antenna via the switching circuit and the low-pass filter in response to the control signal, and the transmitting-and-receiving circuit may be connected to the second antenna via the band-pass filter.

Also, the control unit controls the receiving circuit while generating the control signal, such that the receiving circuit carries out an intermittent receiving operation in a first predetermined time interval as the receiving operation, while one of the first and second antennas is selected. In this case, the control unit may control the transmitting-and-receiving circuit while generating the control signal, such that the transmitting-and-receiving circuit carries out an intermittent receiving operation in a second predetermined time interval as the receiving operation using the second antenna. Also, the control unit may control the intermittent receiving operation of the receiving circuit and the intermittent receiving operation of the transmitting-and-receiving circuit to be independent and asynchronous.

Also, the multiple portable phone may further include a transmitting circuit provided for the first communication system and connectable to the first and second antennas via the switching circuit. In this case, the switching circuit may include first and second switches operatively connecting the receiving circuit to the first antenna. In addition, the switching circuit may further include third and fourth switches operatively connecting the transmitting circuit to the first antenna via the first switch, wherein a node between the third and fourth switches is operatively connected to the second antenna, and a fifth switch operatively connecting the impedance-matching circuit to the second antenna via the first switch. The first to fifth switches are controlled in response to the control signal. Moreover, the switching circuit may further include a sixth switch connected between a first external terminal and a node between the second switch and the receiving circuit. In this case, the sixth switch is controlled in response to the control signal. Also, the switching circuit may further include a seventh switch connected between a second external terminal and the node between the second switch and the receiving circuit, and an eighth

switch connected between the second external terminal and a node between the fourth switch and the transmitting circuit. In this case, the sixth to eighth switches are controlled in response to the control signal.

The impedance-matching circuit may have substantially the same impedance as the receiving circuit. Also, the first communication system may be a PDC system and the second communication system may be a PHS system. In addition, the first antenna may be built-in the phone.

In another aspect of the present invention, an antenna switching method in a multiple portable phone is attained by: (a) selectively connecting a receiving circuit for a first communication system to one of a first antenna and a second antenna via a switching circuit for a receiving operation of the receiving circuit;

(b) connecting a transmitting-and-receiving circuit for a second communication system to the second antenna for a receiving operation of the transmitting-and-receiving circuit; and, (c) compensating impedance change, depending on the switching circuit.

The (a) step may be attained by connecting the receiving circuit to the second antenna via the switching circuit and a low-pass filter, and

the (b) step may be attained by connecting the transmitting and receiving circuit to the second antenna via a band-pass filter.

The (c) step may be attained by selectively connecting an impedance-matching circuit to a path from the second antenna to the transmitting-and-receiving circuit for the receiving operation of the transmitting-and-receiving circuit. In this case, the (c) step includes: connecting the impedance-matching circuit to the path from the second antenna to the transmitting-and-receiving circuit when the transmitting-and-receiving circuit carries out the receiving operation using the second antenna while the receiving circuit carries out the receiving operation using the first antenna.

Also, the receiving operation of the receiving circuit is an intermittent receiving operation in a first predetermined time interval while one of the first and second antennas is selected. The receiving operation of the transmitting-and-receiving circuit is an intermittent receiving operation in a second predetermined time interval using the second antenna. The intermittent receiving operation of the receiving circuit and the intermittent receiving operation of the transmitting-and-

receiving circuit may be independent from each other and asynchronous with each other.

Also, it is desirable that the impedance matching circuit has substantially the same impedance as the receiving circuit. Also, the first communication system is a PDC system, and the second communication system is a PHS system.

Brief Description of the Drawings

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a diagram showing the structure of a conventional multiple portable phone;

Fig. 2 is a diagram showing the structure of a multiple portable phone according to an embodiment of the present invention;

Figs. 3A to 3D are diagrams showing time charts of the intermittent receiving operation according to the embodiment of the present invention; and,

Fig. 4 is a diagram showing a table indicating the switching state of the multiple portable phone according to the embodiment of the present invention.

Description of the Preferred Embodiments

Hereinafter, a multiple portable phone according to the embodiment of the present invention will be described below in detail with

reference to the attached drawings. In the multiple portable phone, a simple portable phone system such as a PHS system is built-in a portable phone such as a PDC system.

Fig. 2 is a block diagram showing the structure of a radio section of the PHS built-in-type PDC according to the embodiment of the present invention. An antenna structure is composed of a PDC/PHS common antenna 102 and a built-in antenna 101. A transmitting-and-receiving structure is composed of a PDC receiving section 107, a PDC transmitting section 108 and a PHS transmitting-and-receiving section 110. As the external terminals, an external terminal 109 and an external terminal 106 are provided. The PDC/PHS common antenna 102 is connected to a node 122 of an antenna switching circuit 103 via a low-pass filter (LPF) of a PDC/PHS common filter 104. Also, the PDC/PHS common antenna 102 is connected to the PHS transmitting-and-receiving section 110 via a band-pass filter (LPF) of the PDC/PHS common filter 104. The built-in antenna 101 is connected with a node 121 of the antenna switching circuit 103. The PDC receiving section 107 and the PDC receiving section 108 are connected with the antenna switching circuit 103 via nodes 123 and

125, respectively. A matching circuit 105 is connected to the antenna switching circuit 103 via a node 124. A control section 111 is connected with the PDC receiving section 107, the PDC transmitting section 108, the PHS transmitting-and-receiving section 110 and the antenna switching circuit 103. Thus, the connection between the PDC built-in antenna 101, the PDC/PHS common filter 104, and the external terminals 106 and 109 and each transmitting-and-receiving sections is controlled by the antenna switching circuit 103 based on control signals from the control section 111.

The antenna switching circuit 103 is provided with switches SW1 to SW8. The switch SW1 is provided between the node 121 and a node 126, and the switch SW2 is provided between the external terminal 106 and the node 123. The switch SW3 is provided between the node 126 and the node 123, and the switch SW4 is provided between the node 126 and the node 122. The switch SW5 is provided between the node 123 and the external terminal 109, and the switch SW6 is provided between the node 122 and the node 125. The switch SW7 is provided between the node 125 and the external terminal 109, and the switch SW8 is provided between the node 122 and the node 124.

Thus, the switches SW1 and SW3 connect the built-in antenna 101 and the PDC receiving section 107. The switches SW3 and SW4 connect the PDC/PHS common antenna 102 and the PDC receiving section 107. The switch SW6 connects the PDC/PHS common antenna 102 and the PDC transmitting section 108. The switch SW8 connects the PDC/PHS common antenna 102 and the matching circuit 105. The switches SW5 and SW7 connect the external terminal 109 with the PDC receiving section 107 or the PDC transmitting section 108. The switch SW2 connects the external terminal 106 and the PDC receiving section 107. Each of the switches SW1 to SW8 of the antenna switching circuit 103 is switched based on the control signals CTL ①, CTL ② and CTL ③ from the control unit 111.

In this embodiment, the PDC/PHS common filter 104 is provided to carry out frequency-division or frequency-synthesization of the signal of a PDC frequency band and the signal of a PHS frequency band from the PDC/PHS common antenna 102. The output section of the PDC/PHS common filter on the PDC side is composed of LPF (Low-Pass Filter) and the output section thereof on the PHS side is composed of BPF (Band-Pass Filter). Also, the PDC side terminal of LPF is connected with the antenna switching circuit 103

via the node 122 and the PHS side terminal of BPF is connected with the PHS transmitting-and-receiving section.

The outline of the function of each section is as follows.

The PHS transmitting-and-receiving section 110 carries out division and wave-synthesization of the PHS data and the PDC data by the PDC/PHS common filter 104, and transmission and reception are carried out by the PDC/PHS common antenna 102. A signal is received by the PHS transmitting-and-receiving section 110, and demodulated and supplied to the control unit 111. The PDC receiving section 107 is connected with either of the PDC built-in antenna 101 and the PDC/PHS common antenna 102. A signal obtained by receiving and demodulating the PDC data is supplied to the control unit 111. Also, a transmission signal is outputted from the PDC transmitting section 108 and the PHS transmitting-and-receiving section 110 is transmitted through the PDC/PHS common antenna 102.

The control unit 111 carries out the process for the PHS reception data and the PDC reception data supplied from the PHS transmitting-and-receiving section 110 and the PDC receiving section 107, a transmission of data to the PDC

transmitting section, and a process for a sound data. Also, the control unit 111 carries out a synchronization-establishing process in an intermittent receiving operation and a process for control data such as an originating call and a terminating call in the intermittent receiving operation. Especially, the control unit 111 carries out the control of the synchronizing process of the intermittent receiving operation in the PDC receiving section 107 and the PHS transmitting-and-receiving section 110. Thus, on the basis of the reception data in the intermittent receiving operation, the reception timing is set to a timing at which the terminating call data can be obtained in the intermittent receiving operations of the PDC receiving section and the PHS receiving section. Also, for such control, the control unit 111 outputs binary control signals CTL ① to ③ ("H" and "L") to the antenna switching integrated circuit 103 to switch the states of SW1 to SW8.

For example, as shown in Fig. 4, when the PDC receiving section 107 carries out a receiving operation using the PDC/PHS common antenna 102, the switches SW1, SW2, SW5, SW6, SW7 and SW8 are set to the turning off state, and the switches SW3 and SW4 are set to the turning-on state. When

the PDC receiving section 107 carries out a receiving operation using built-in antenna 101, the switches SW2, SW4, SW5, SW6, and SW7 are set to the turning-off state, and the switches SW1, SWSW3 and SW8 are set to the turning-on state. When the PDC transmitting section 108 carries out a transmitting operation using the PDC/PHS common antenna 102, the switches SW1, SW2, SW3, SW4, SW5, SW7, and SW8 are set to the turning-off state, and the switch SW6 is set to the turning-on state. When the PDC receiving section 107 carries out a receiving operation using the external terminal 109, the switches SW1, SW2, SW3, SW4, SW6, SW7, and SW8 are set to the turning-off state, and the switch SW5 is set to the turning-on state. When the PDC receiving section 107 carries out a receiving operation using the external terminal 106, the switches SW1, SW3, SW4, SW5, SW6, and SW7 are set to the turning-off state, and the switches SW2 and SW8 are set to the turning-on state. When the PDC transmitting section 108 carries out a transmitting operation using the external terminal 109, the switches SW1, SW2, SW3, SW4, SW5, SW6, and SW8 are set to the turning-off state, and the switch SW7 is set to the turning-on state.

For example, the switch SW1 103A and the

switch SW3 103C are set to the turning-on in the antenna switching circuit 103, the built-in antenna 101 is selected. Also, the switch SW3 103C and the switch SW4 103D are set to the turning-on state in the antenna switching circuit 103, the PDC/PHS common antenna 102 is selected. When the switch SW1 103A and the switch SW3 103C are turned-on to select the built-in antenna 101, the switch SW4 103D is set to the turning-off state to disconnect the PDC/PHS common antenna 102. In this case, because the transmitting operation is not carried out, the switch SW6 103F is set to the turning-off state.

When the external terminal 109 or 106 is used to be connected with an antenna such as an adapter mounted on a car, either of the switch SW5, the switch SW7 and the switch SW2 is set to the turning-on state. The other switches are set to the turning-off state in addition to the switch SW1, the switch SW3, the switch SW4, and the switch SW6.

It should be noted that the above-mentioned radio section structure of the PHS transmitting and receiving section and the PDC transmitting and receiving section are well-known by a person in the art. Also, the radio section is not directly related to the present invention.

Therefore, the detailed description is omitted.

Next, the operation in this embodiment will be described with reference to Figs. 3A to 3D and Fig. 4.

In the multiple radio terminal of a radio phone (PDC) and a simple radio phone (PHS), an intermittent receiving operation is carried out in both of the PDC side and the PHS side to reduce power consumption.

As shown in Figs. 3A and 3D, the PDC side intermittently carries out a superframe reception in the interval of 720 ms (201), and the PHS side intermittently carries out a superframe reception in the interval of 1.2 s (204). Also, as shown in Figs. 3B and 3C, the intermittent receiving operation on the PDC side is carried out by switching between the PDC/PHS common antenna 102 and the PDC built-in antenna 101 at the period of 720 ms. As shown in Fig. 3D, the PHS side carries out the intermittent receiving operation at the interval of 1.2 s in asynchronous with the operation of the common antenna on the PDC side.

Also, as shown in Fig. 4, the switch SW3 and the switch SW4 are set to the turning-on state based on the control signals CTL① to ③, when the PDC side carries out the receiving operation using the PDC/PHS common antenna (301).

At this time, the PDC receiving section 107 receives the PDC wave from the PDC/PHS common antenna 102 through LPF of the PDC/PHS common filter 104 and switch SW3 and switch SW4. Also, when the PDC side carries out the receiving operation using the built-in antenna (302), the switch SW1, the switch SW3 and the switch SW8 are set to the turning-on state. At this time, the PDC receiving section 107 receives the PDC wave from the PDC built-in antenna 101 through the switch SW1 and the switch SW3. It should be noted that when the PDC side carries out the transmitting operation using the PDC/PHS common antenna (303), the switch SW6 is set to the turning-on state and all other switches are set to the turning-off state.

In the above, a system may be adopted in which the mutual relation of the respective reception timings of the PDC side and the PHS side is asynchronously controlled by the control unit 111. In this case, until there is a terminating call or an originating call to reduce the load of the control, the PDC side carries out the selection (202) of the PDC/PHS common antenna 102 or the selection (203) of the built-in antenna, irrespective of the operation on the PHS side.

It is supposed that the PHS side starts the receiving operation using the PDC/PHS common antenna 102 (204A) after the PDC side selects the PDC/PHS common antenna 102 and starts the receiving operation (202A). In this case, the switch SW4 and the switch SW3 are set to the turning on state and the PDC/PHS common filter 104 and the PDC receiving section 107 are connected to each other. This is because the switch SW states (301) of the antenna switching circuit 103 are maintained until the time of the next reception on the PDC side. Also, the matching condition of the PDC/PHS common filter 104 is not changed and the PHS side can be normally received at the timing of 204A.

However, it is supposed that the intermittent receiving operation timing on the PDC side and the intermittent receiving operation timing on the PHS side become the same. It is supposed that the PDC side selects a built-in antenna (203A). The switch SW4 and the switch SW6 are set to the turning-off state and the switch SW8 is set to the turning-on state (302) in the switch SW states of the antenna switching circuit 103. As a result, the PDC/PHS common antenna 102 is disconnected from the PDC receiving section 107. However, since switch SW8 is set to the

turning-on state, the matching circuit 105 is connected with the output side of LPF of the PDC/PHS common filter 104. Here, the impedance of the matching circuit 105 is set to be equal to the impedance when the PDC transmitting circuit or the PDC receiving circuit is connected.

Therefore, in this case, the matching condition of the PDC/PHS common filter 104 never changes. Also, the PHS side can carry out a normal receiving operation at the timing of 204B. It should be noted that a case where the reception timings on the PDC side and the reception timing on the PHS side are incident with each other by chance, an example of the intermittent receiving operation timing is described. However, when the intermittent receiving operation on the PHS side is carried out after the PDC side selects the built-in antenna, until the antenna is switched to the PDC/PHS common antenna 102 on the PDC side, the similar operation is carried out.

In this way, the reliability of the synchronization holding is increased about the intermittent-receiving operation timing of the PHS transmission and reception circuit, and it is possible to prevent the synchronization from going out. As a result, the PHS transmitting-and-

receiving circuit can be switched from the intermittent receiving operation to the continuous receiving operation so that it is possible to avoid continuation of the synchronous establishing operation in the intermittent-receiving operation timing.

In the above embodiment, the common filter is adopted for the filter for the PDC wave and the filter for the PHS wave, and the example in which the common filter is connected between the PDC/PHS common antenna and the antenna switching circuit 103 is described. However, the filter on the PHS side may be arranged between the antenna switching circuit 103 and the PHS transmitting-and-receiving section 110, and the filter on the PDC side may be arranged between the antenna switching circuit 103 and the PDC receiving section 107.

As mentioned above, according to the present invention, when switch SW8 103H is set to the turning-on state so as not to change an antenna matching condition on the side of the antenna switching circuit 103, the matching circuit 105 is connected with the antenna side, and the PDC receiving section 107 selects the PDC built-in antenna 101 and carries out the receiving operation, it becomes possible to keep

the reception characteristic on the PHS side to be constant, by avoiding an influence on the antenna-matching condition on the PHS side, even if the PHS transmitting-and-receiving section 110 carries out the transmitting operation and receiving operation.

According to the present invention, when the antenna switching switch is switched to use the side of the built-in antenna by the diversity operation on the PDC side, the impedance on the side of the PDC/PHS common antenna is fixed by the matching circuit. Therefore, there is no case that the matching state of the impedance of the PDC/PHS common antenna becomes unstable, and it can prevent the degradation of the transmission-and-reception characteristic on the PHS side in case of the reception by use of the PDC built-in antenna. Especially, when the PDC/PHS common filter is connected with the PDC/PHS common antenna, the reception degradation on the PHS side due to characteristic degradation of the PDC/PHS common filter can be prevented in case of selection of the built-in antenna by the antenna switching switch.

Also, according to the present invention, when an intermittent receiving operation is carried out in the PDC receiving section and the

PHS receiving section, the intermittent receiving operation on the PHS side becomes stable and synchronization-holding is warranted. Therefore, the synchronization going-out due to reception failure which is based on characteristic degradation of the PDC/PHS common filter and so on can be prevented. Also, the continuous receiving operation for the sync-signal detection becomes unnecessary in case of synchronization going-outs in the intermittent receiving operation, and the power consumption can be restrained.

Also, the antenna switching circuit of the present invention has a simple structure in which the single switch is provided for the antenna switching integrated circuit and a connection terminal of the matching circuit which is connected with an external matching circuit, and faults in the PHS reception can be avoided. The increase of the used parts, the use of the dedicated line and so on are unnecessary, and it becomes possible for a printed wiring board to be made small and to be made in high density.

While the present invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of

description rather than limitation, and changes may be made to the invention without departing from its scope as defined by the appended claims.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.

In a multiple portable phone, a first antenna is provided for a first communication system, a second antenna is provided in common to the first communication system and a second communication system. A switching circuit is controlled based on a control signal. A receiving circuit is provided for the first communication system and is connected to one of the first and second antennas via the switching circuit. A transmitting-and-receiving circuit is provided for the second communication system and is connected to the second antenna. A control unit generates the control signal to control the switching circuit to connect an impedance-matching circuit to a path from the second antenna to the transmitting-and-receiving circuit when the transmitting-and-receiving circuit carries out a receiving operation using the second antenna while the receiving circuit carries out a receiving operation using the first antenna.

CLAIMS:

1. A multiple portable phone comprising:

a first antenna for a first communication system;

a second antenna common to said first communication system and a second communication system;

a switching circuit controlled based on a control signal;

a receiving circuit provided for said first communication system, and connectable to said first and second antennas via said switching circuit;

a transmitting-and-receiving circuit provided for said second communication system, and connectable to said second antenna;

an impedance matching circuit connected to said switching circuit; and,

a control unit generating said control signal to control said switching circuit to connect said impedance-matching circuit to a path from said second antenna to said transmitting-and-receiving circuit to enable said transmitting-and-receiving circuit to carry out a receiving operation using said second antenna while said receiving circuit is connected to said first antenna.

2. The multiple portable phone according to claim

1, further comprising a common filter of a low-pass filter and a band-pass filter, and,

wherein said receiving circuit is connected to said second antenna via said switching circuit and said low-pass filter in response to said control signal, and said transmitting and receiving circuit is connected to said second antenna via said band-pass filter.

3. The multiple portable phone according to claim 1 or 2, wherein said control unit controls said receiving circuit while generating said control signal, such that said receiving circuit carries out an intermittent receiving operation in a first predetermined time interval as said receiving operation while one of said first and second antennas is selected.

4. The multiple portable phone according to claim 3, wherein said control unit controls said transmitting-and-receiving circuit while generating said control signal, such that said transmitting-and-receiving circuit carries out an intermittent receiving operation in a second predetermined time interval as said receiving operation using said second antenna.

5. The multiple portable phone according to claim 4, wherein said control unit controls said intermittent receiving operation of said receiving circuit and said intermittent receiving operation of said transmitting and receiving circuit to be independent and asynchronous.

6. The multiple portable phone according to any of claims 1 to 5, further comprising a transmitting circuit provided for said first communication system, and connectable to said first and second antennas via said switching circuit, and,

wherein said switching circuit comprises:

first and second switches operatively connecting said receiving circuit to said first antenna;

third and fourth switches operatively connecting said transmitting circuit to said first antenna via said first switch, wherein a node between said third and fourth switches is operatively connected to said second antenna; and,

a fifth switch operatively connecting said impedance-matching circuit to said second antenna via said first switch,

wherein said first to fifth switches are controlled in response to said control signal.

7. The multiple portable phone according to claim 6, wherein said switching circuit further comprises:

a sixth switch connected between a first external terminal and a node between said second switch and said receiving circuit, and,

wherein said sixth switch is controlled in response to said control signal.

8. The multiple portable phone according to claim 6, wherein said switching circuit further comprises:

a seventh switch connected between a second external terminal and the node between said second switch and said receiving circuit; and,

an eighth switch connected between said second external terminal and a node between said fourth switch and said transmitting circuit, and,

wherein said sixth to eighth switches are controlled in response to said control signal.

9. The multiple portable phone according to any of claims 1 to 8, wherein said impedance-matching circuit has substantially the same impedance as the receiving circuit.

10. The multiple portable phone according to any of claims 1 to 9, wherein said first communication system is a PDC system and said second communication system

is a PHS system.

11. The multiple portable phone according to any of claims 1 to 10, wherein said first antenna is built-in said phone.

12. A antenna switching method in a multiple portable phone comprising:

(a) selectively connecting a receiving circuit for a first communication system to one of a first antenna and a second antenna via a switching circuit for a receiving operation of said receiving circuit;

(b) connecting a transmitting-and-receiving circuit for a second communication system to said second antenna for a receiving operation of said transmitting and receiving circuit; and,

(c) compensating impedance change depending on said switching circuit.

13. The method according to claim 12, wherein said (a) step includes:

connecting said receiving circuit to said second antenna via said switching circuit and a low-pass filter, and,

said (b) step includes:

connecting said transmitting-and-receiving circuit to said second antenna via a band-pass filter.

14. The method according to claim 12 or 13, wherein said (c) step includes:

selectively connecting an impedance-matching circuit to a path from said second antenna to said transmitting-and-receiving circuit for said receiving operation of said transmitting-and-receiving circuit.

15. The method according to claim 14, wherein said (c) step includes:

connecting said impedance-matching circuit to said path from said second antenna to said transmitting-and-receiving circuit when said transmitting-and-receiving circuit carries out said receiving operation using said second antenna while said receiving circuit carries out said receiving operation using said first antenna.

16. The method according to any of claims 12 to 15, wherein said receiving operation of said receiving circuit is an intermittent receiving operation in a first predetermined time interval while one of said first and second antennas is selected.

17. The method according to claim 16, wherein said receiving operation of said transmitting-and-receiving circuit is an intermittent receiving operation in a second predetermined time interval using said second

antenna.

18. The method according to claim 17, wherein said intermittent receiving operation of said receiving circuit and said intermittent receiving operation of said transmitting-and-receiving circuit are independent from each other and asynchronous with each other.

19. The method according to any of claims 12 to 18, wherein said impedance matching circuit has substantially the same impedance as the receiving circuit.

20. The method according to any of claims 12 to 19, wherein said first communication system is a PDC system and said second communication system is a PHS system.

21. A multiple portable phone substantially as herein described with reference to and as shown in Figures 2 to 4 of the accompanying drawings.

22. An antenna switching method substantially as herein described with reference to and as shown in Figures 2 to 4 of the accompanying drawings.

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4L (LDDRS, LDDRX, LEP), H1Q (QHC)

Int Cl (Ed.7): H04B 1/18, 1/38, 1/40, 1/44, 1/48, 7/04, 7/08, H04Q 7/32

Other: Online Databases: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP0823751 A2	(NOKIA) fig.6 & col.6 line 39 - col.7 line 37	12, 14, 20
X	JP070007462 A	(TOSHIBA) see fig.1 & WPI abstract	12, 20

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.